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Correlation and path coefficient analysis for yield and its components in okra (*Abelmoschus esculentus* (L.) Moench)

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ABSTRACT

Twenty-four entries okra (*Abelmoschus esculentus* (L.) Moench), were evaluated in randomized block design with three replications at the Experimental Farm, Vegetable Research Station, Rajendranagar, Hyderabad, Andhra Pradesh, India during *summer* 2013. Correlation and path coefficient analyses revealed that total number of fruits per plant and total yield per plant not only had positively significant association with marketable pod yield per plant, but also had positively high direct effect on marketable pod yield per plant and are regarded as the main determinants of marketable pod yield per plant and direct selection through these traits will be effective. The genotypic correlation coefficient of plant height, number of branches per plant, intermodal length, fruit length, fruit weight and number of marketable fruits per plant with marketable yield per plant was significantly positive, but their direct effect on marketable yield per plant was negative or negligible suggesting that the indirect casual factors are to be considered simultaneously for selection. Total number of fruits per plant and total yield per plant had strong influence on marketable pod yield per plant and are the main determiners of marketable pod yield per plant.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is popularly known as lady's finger or okra belongs to the class dicotyledonae, order Malvales, family Malvaceae and genus *Abelmoschus* (syn. *Hibiscus*) (Schippers, 2000). It is native to West Africa (Murdock, 1959). It is grown extensively in tropical, subtropical and Mediterranean climatic zones of the world (Hammon and Van Sloten, 1989). It is a multipurpose crop valued for its tender and delicious pods (Chinatu and Okocha, 2006). It is grown extensively in tropical, subtropical and Mediterranean climatic zones of the world (Hammon and Van Sloten, 1989). It is a multipurpose crop valued for its tender and delicious pods (Chinatu and Okocha, 2006). It is a powerhouse of valuable nutrients, low in calories, fat-free and provides a valuable supplementary nutrition in human diet in developing countries where there is often a great alimentary imbalance (Kumar and Sreeparvathy, 2010). It has good medicinal value with its antispasmodic, demulcent, diaphoretic, diuretic, emollient, stimulant and vulnery properties

(Mehta, 1959; Nadkarni, 1972). Its potential as an industrial crop also has been tested in the developed world (Camciuc *et al*., 1998). Okra has got potential to boost food, nutritional and health security, foster rural development and support sustainable land utilization (Reddy, 2010).

Okra is an important vegetable crop in India, West Africa, South-East, Asia, USA, Brazil, Australia and Turkey. It is the most important fruit vegetable crop in India. As it is a tropical, hot weather, low land crop and susceptible to low night temperatures, it is extensively cultivated in *kharif* and summer seasons in India. Being an upright, quick growing and medium duration annual herb, it fits well into multiple cropping systems either as a sole crop or intercrop (Reddy, 2010). Optimizing pod yield is one of the most important goals for most okra growers and, consequently, most okra breeding programmes. For improving this crop through conventional breeding and selection, adequate knowledge of association that exists between yield and yield related characters is essential for the identification of selection procedure.

In okra, all growth, earliness and yield associated traits are quantitative in nature. Such characters are controlled by polygenes and are much influenced by environmental fluctuations. Pod yield of okra is a complex quantitative trait, which is conditioned by the interaction of various growth and physiological processes throughout the life cycle (Adeniji and Peter, 2005). Improvement of complex characters such as pod yield may be accomplished through the component approach of breeding. The development of plant breeding strategy hinges mainly on the support provided by genetic information on inheritance and behavior of major quantitative characters associated with yield and yield components (Arunachalam, 1976). A better understanding of the contribution of each trait in building up the genetic makeup of the crop may be obtained through yield component analysis. Determination of the yield components through correlation and path coefficient analyses will improve the efficiency of a breeding programme. Plant height, number of branches per plant, internodal length, fruit length, fruit weight and number of fruits per plant were identified as the yield components in okra (Bendale *et al*., 2003b; Jaiprakashnarayan and Mulge, 2004; Bello *et al*., 2006; Mehta *et al*., 2006; Patro and Sankar, 2006; Singh *et al*., 2006; Mohapatra *et al*., 2007; Pal *et al*., 2008; Rashwan, 2011; Somashekhar *et al*., 2011).

Correlation and path coefficient analyses are prerequisites for improvement of any crop including okra for selection of superior genotypes and improvement of any trait. In plant breeding, correlation analysis provides information about yield components and thus helps in selection of superior genotypes from diverse genetic populations. The correlation studies simply measure the associations between yield and other traits. Usefulness of the information obtained from the correlations coefficients can be enhanced by partitioning into direct and indirect effects for a set of a pair-wise cause-effect inter relationships (Kang *et al*., 1983). Path coefficient analysis permits the separation of correlation coefficient into direct and indirect effects. It is basically a standardized partial regression analysis and deals with a closed system of variables that are linearly related. Such information provides realistic basis for allocation of appropriate weightage to various yield components. In okra, correlation and path coefficient analyses have been used by several researchers to measure the associations between yield and other traits and to clarify interrelation between pod yield and other traits, respectively. Highly significant associations of pod yield were observed with plant height (Bello *et al*., 2006; Mehta *et al*., 2006; Patro and Sankar, 2006; Somashekhar *et al*., 2011), number of branches per plant (Mehta *et al*., 2006; Patro and Sankar, 2006; Singh *et al*., 2006; Rashwan 2011; Somashekhar *et al*., 2011), internodal length (Mohapatra *et al*., 2007; Somashekhar *et al*., 2011), days to 50% flowering (Bello *et al*., 2006; Mehta *et al*., 2006; Singh *et al*., 2006; Rashwan 2011; Somashekhar *et al*., 2011), first flowering node (Jaiprakashnarayan and Mulge, 2004; Singh *et al*., 2006), first fruiting node (Jaiprakashnarayan and Mulge, 2004), fruit length (Bendale *et al*., 2003; Jaiprakashnarayan and Mulge, 2004; Mehta *et al*., 2006; Patro and Sankar, 2006; Singh *et al*., 2006; Pal *et al*., 2008; Somashekhar *et al*., 2011), fruit width (Mohapatra *et al*., 2007; Pal *et al*., 2008; Rashwan 2011; Somashekhar *et al*., 2011), fruit weight (Bendale *et al*., 2003; Jaiprakashnarayan and Mulge, 2004; Mehta *et al*., 2006; Patro and Sankar, 2006; Singh *et al*., 2006; Mohapatra *et al*., 2007; Pal *et al*., 2008; Rashwan 2011; Somashekhar *et al*., 2011), total number of fruits per plant (Bendale *et al*., 2003; Jaiprakashnarayan and Mulge, 2004; Bello *et al*., 2006; Singh *et al*., 2006; Mohapatra *et al*., 2007; Pal *et al*., 2008; Rashwan 2011; Somashekhar *et al*., 2011). Pod yield has been reported to be influenced by high direct effects of plant height (Mehta *et al*., 2006), number of branches per plant (Mehta *et al*., 2006), internodal length (Mohapatra *et al*., 2007), fruit length (Mehta *et al*., 2006; Patro and Sankar, 2006), fruit weight (Jaiprakashnarayan and Mulge, 2004; Mehta *et al*., 2006; Patro and Sankar, 2006), total number of fruits per plant (Jaiprakashnarayan and Mulge, 2004; Patro and Sankar, 2006; Mohapatra *et al*., 2007). Plant height, number of branches per plant, internodal length, fruit length, fruit weight and number of fruits per plant were identified as potential selection criteria in breeding programmes aiming at higher yield. In this study, an attempt was made to study the interrelationship among characters and the direct and indirect effects of some important yield components on pod yield in 24 entries by adopting correlation and path co-efficient analysis.

Materials and Methods

Experimental material comprised of 24 entries of okra including 15 F_1 hybrids, six parental lines and three standard checks [‘No. 64’ (Mahyco), ‘Avantika’ (Bioseed) and ‘Shakti’ (Nunhems)]. All entries were evaluated in a randomized block design with three replications at the Vegetable Research Station, Rajendranagar, Hyderabad, Andhra Pradesh, India during *summer*, 2013. Each genotype was grown in a double row plot of 3 m length and 1.2 m width. Each plot consisted of two ridges alternating with furrows accommodating two rows of genotype. A row-to-row spacing of 60 cm and a plant-to-plant spacing of 30 cm was maintained. Two seeds per hill were sown on the shoulder of the ridge and later thinned to one plant per hill at two weeks after sowing, giving a plant density of ten plants per row and 20 plants per plot and entry. Cultural and agronomic practices were followed as per the standard recommendations and need based plant protection measures were taken up to maintain healthy crop stand. Observations were recorded for seventeen quantitative characters were recorded on five competitive and randomly selected plants in each replication for all the characters under study except days to fifty percent flowering, total number of fruits per plant, number of marketable fruits per plant, total yield per plant, marketable yield per plant, percent fruit and shoot borer infestation on shoots and fruits and percent yellow vein mosaic virus infestation on plants and fruits, which were recorded on whole plot basis. The mean for each trait over two replications was computed for each genotype and analyzed statistically. The analysis was carried out by applying standard statistical techniques for analysis of variance to establish significance level among genotypes as described by Singh and Chaudhary (1985) and Steel and Torrie (1980). The correlation coefficient analysis was performed according to the method suggested by Weber and Moorthy (1952). Path coefficient analysis was carried out following the methods of Singh and Chaudhary (1985) and Steel and Torrie (1980).

Result and Discussion:

Complex characteristics such as yield must be related to many individually distinguishable characteristics. It is obvious that fruit yield is a complex character that depends up on many independent yield contributing characters, which are regarded as yield components. All changes in the components need not however, be expressed by changes in yield. This is due to varying degree of positive and negative associations between yield and its components and among components themselves. Therefore, selection should be based on these component characters after assessing their association with fruit yield per plant.

Correlation Coefficient Analysis

From the perusal of the estimates of phenotypic and genotypic coefficients of variation, in general, it was observed that the estimates of genotypic correlation coefficients were in most cases higher than their corresponding phenotypic correlation coefficients. Further, the genotypic correlation coefficient between different characters pairs was similar in sign and nature to the corresponding phenotypic correlation coefficient. The present findings are in consonance with the earlier findings of Akinyele and Osekita (2006), Bello *et al*. (2006), Mehta *et al*. (2006), Rashwan (2011) and Somashekhar *et al*. (2011). More significant genotypic association between the different pairs of characters than the phenotypic correlation means that there is strong association between those characters genetically, but the phenotypic value is lessened by the significant interaction of environment (Table 1).

Phenotypic correlation

In the present study, plant height had significantly positive correlation with number of branches per plant, internodal length, fruit length, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant and it had significantly negative correlation with FSB infestation on fruits and shoots. Number of branches per plant had significantly positive association with plant height, internodal length, fruit length, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant and it had significantly negative association with FSB infestation on fruits and shoots. Internodal length was positively correlated with plant height, number of branches per plant, fruit length, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant, while it was negatively correlated with first flowering node, first fruiting node and FSB infestation on fruits and shoots. Days to 50% flowering had significantly positive correlation with fruit width. First flowering node was negatively correlated with internodal length. First fruiting node had significantly negative correlation with plant height and internodal length. In the present study, fruit length was positively correlated with plant height, number of branches per plant, internodal length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant, and it was negatively correlated with FSB infestation on fruits and shoots. Fruit width had significantly positive correlation with days to 50% flowering, fruit weight, total yield per plant and marketable yield per plant. Fruit weight had significantly positive correlation with fruit length, fruit width, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant, while it had significantly negative correlation with FSB infestation on fruits and shoots. Total number of fruits per plant was positively correlated with plant height, number of branches per plant, internodal length, fruit length, fruit weight, number of marketable fruits per plant, total yield per plant and marketable yield per plant and it was negatively correlated with FSB infestation on fruits and shoots. Number of marketable fruits per plant had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, total yield per plant and marketable yield per plant and it had significantly negative correlation with FSB infestation on fruits and shoots. Total yield per plant was positively correlated with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant and marketable yield per plant, while it had significantly negative correlation with FSB infestation on fruits and shoots. Marketable yield per plant was positively correlated with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant and total yield per plant and negatively correlated with FSB infestation on fruits and shoots. FSB infestation on fruits had significantly positive correlation with FSB infestation on shoots, while it had significantly negative correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant. FSB infestation on shoots was positively correlated with days to 50% flowering, first flowering node, first fruiting node, FSB infestation on fruits, while it was negatively correlated with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant. On the whole, marketable yield per plant had significantly positive phenotypic correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant and total yield per plant and it had significantly negative correlation with FSB infestation on fruits.

Genotypic correlation

In the present study, plant height had significantly positive correlation with number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant, while it had significantly negative correlation with first flowering node and first fruiting node and FSB infestation on fruits and shoots. Similar positive association of fruit yield was reported by Jaiprakashnarayan and Mulge (2004), Bello *et al*. (2006), Dakahe *et al*. (2007) and Somashekhar *et al.* (2011) for plant height, Mehta *et al*. (2006) for number of branches per plant, Singh *et al*. (2006) for fruit length, fruit weight and number of fruits per plant, while negative association of total yield with internodal length was reported by Somashekhar *et al.* (2011), first flowering and fruiting node was reported by Jaiprakashnarayan and Mulge (2004). Positive association of plant height with internodal length and total number of fruits per plant was reported by Somashekhar *et al.* (2011). Number of branches per plant had significantly positive correlation with plant height, internodal length, fruit length, fruit weight, total number of fruit per plant, number of marketable fruit per plant, total yield per plant and marketable yield per plant and it had significantly negative correlation with first flowering node, first fruiting node and FSB infestation on fruits and shoots. Mehta *et al*. (2006) reported negative association of number of branches per plant with total yield per plant in okra. Internodal length had significantly positive correlation with plant height, number of branches per plant, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant, while it had significantly negative correlation with days to 50% flowering, first flowering node, first fruiting node and FSB infestation on shoots. These findings are in agreement with the earlier findings of Somashekhar *et al.* (2011) who also observed positive association between plant height and internodal length. In the present study, days to 50% flowering had significantly positive correlation with first flowering node, first fruiting node, fruit width and FSB infestation on shoots, while it had significantly negative correlation with number of branches per plant, intermodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant. Positive association of days to 50% flowering with first flowering node and first fruiting node was also reported by Jaiprakashnarayan and Mulge (2004). Somashekhar *et al.* (2011) also observed negative association between days to 50% flowering and fruit yield. First flowering node had significantly positive correlation with days to 50% flowering, first fruiting node, fruit width and FSB infestation on shoots, while it had significantly negative correlation with plant height, number of branches per plant, internodal length, fruit length, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant. First fruiting node had significantly positive correlation with days to 50% flowering, first flowering node, fruit width, FSB infestation on shoots, while it had significantly negative correlation with plant height, number of branches per plant, internodal length, fruit length, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant. In this study, first flowering node had perfect positive correlation with first fruiting node, indicating cent per cent fruit set in the early stages of flowering and fruiting in the material under study. On the whole, all these three earliness attributes showed negative correlation with total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable pod yield per plant. In the present study, fruit length had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant and had significantly negative correlation with days to 50% flowering, first flowering node, first fruiting node, fruit width and FSB infestation on fruits and shoots. Fruit width had significantly positive correlation with days to 50% flowering, first flowering node, first fruiting node, fruit weight and it had significantly negative correlation with fruit length. Fruit weight had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit length, fruit width, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant, while it had significantly negative correlation with days to 50% flowering and FSB infestation on fruits and shoots. Total number of fruits per plant had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, number of marketable fruits per plant, total yield per plant and marketable yield per plant and it had significantly negative correlation with days to 50% flowering, first flowering node, first fruiting node, FSB infestation on fruits and shoots.

Number of marketable fruits per plant had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, total yield per plant and marketable yield per plant and it had significantly negative correlation with days to 50% flowering, first flowering node, first fruiting node and FSB infestation on fruits and shoots. All the fruit traits like fruit length, fruit width, fruit weight, total number of fruits per plant and number of marketable fruits per plant showed significantly positive association with fruit yield per plant and also among themselves except fruit width.

The present findings are in consonance with the earlier findings of Bello *et al*. (2006) and Mehta *et al.* (2006) who also reported positive association of fruit length, fruit weight and total number of fruits per plant with total yield per plant in okra. Positive association of fruit length with fruit weight and total yield per plant was reported by Dakahe *et al*. (2007) and Jaiprakashnarayan and Mulge (2004), respectively.

Total yield per plant had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant and marketable yield per plant and it had significantly negative correlation with internodal length, days to 50% flowering, first flowering node, first fruiting node and FSB infestation on fruits and shoots.

Similar association of total yield per plant was also observed by Somashekhar *et al*. (2011) for plant height, internodal length, fruit length, fruit width, fruit weight and total number of fruits per plant, Mehta *et al*. (2006) for number of branches per plant, days to 50% flowering, Jaiprakashnarayan and Mulge (2004) for first flowering node and first fruiting node in okra. Marketable yield per plant had significantly positive correlation with plant height, number of branches per plant, internodal length, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant and total yield per plant and it had significantly negative correlation with days to 50% flowering, first flowering node, first fruiting node and FSB infestation on fruits and shoots. Similar association of marketable yield per plant was also observed by Pal *et al*. (2008) for fruit length, fruit width, fruit weight, total number of fruits per plant and total yield per plant in okra.

FSB infestation on fruits had significantly positive correlation with FSB infestation on shoots, while it had significantly negative correlation with plant height, number of branches per plant, fruit length, fruit weight, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant. FSB infestation on shoots had significantly positive correlation with FSB infestation on fruits, while it had significantly negative correlation with plant height, number of branches per plant, internodal length, fruit length, total number of fruits per plant, number of marketable fruits per plant, total yield per plant and marketable yield per plant.

On the whole, marketable yield per plant had significantly positive genotypic correlation with plant height, number of branches per plant, internodal length, fruit width, fruit weight, total number of fruits per plant, number of marketable fruits per plant and total yield per plant and it had significantly negative correlation with FSB infestation on fruits.

Path Coefficient Analysis

Partioning of the genotypic correlation coefficient of different components with grain yield into direct and indirect effect was done and results are presented in Table 2. At genotypic level, plant height, fruit length, fruit width and fruit weight had positively negligible direct effect on marketable yield per plant, while number of branches per plant, internodal length, days to 50% flowering, first flowering node and first fruiting node, FSB infestation on shoots had negatively negligible direct effect on marketable yield per plant. FSB infestation on fruits had negatively low direct effect on marketable yield per plant.

Total number of fruit per plant had positively high direct effect on marketable yield per plant. Number of marketable fruits per plant and total yield per plant had very high negatively and positively direct effects, respectively on marketable yield per plant.

At phenotypic level, plant height, fruit length, fruit width and fruit weight had positively negligible direct effect on marketable yield per plant, while number of branches per plant, internodal length, days to 50% flowering, first flowering node, first fruiting node, FSB infestation on shoots had negatively negligible direct effect on marketable yield per plant. FSB infestation on fruits had negatively low direct effect on marketable yield per plant.

Total number of fruits per plant had positively high direct effect on marketable yield per plant. Number of marketable fruits per plant and total yield per plant had very high negatively and positively direct effects, respectively on marketable yield per plant.

Number of branches per plant, internodal length, days to 50% flowering, first flowering node, first fruiting node, FSB infestation on shoots had positively negligible direct effect, while plant height, fruit length, fruit width and fruit weight had negatively negligible direct effect on marketable yield per plant.

Total number of fruits per plant and FSB infestation on fruits had positively and negatively moderate direct effect, respectively on marketable yield per plant. Number of marketable fruits per plant and total yield per plant had negatively and positively high direct effect, respectively on marketable yield per plant. The genotypic direct effect of total number of fruits per plant and total yield per plant with marketable yield per plant (0.8650 and 1.0231, respectively) was almost equal to their genotypic correlation coefficient with marketable yield per plant (0.9936^{**} and 1.0013^{**}, respectively). Thus correlation explains the true relationship between total number of fruits per plant and marketable yield per plant and total yield per plant and marketable yield per plant and direct selection through these traits will be effective. The genotypic correlation coefficient of plant height, number of branches per plant, intermodal length, fruit length and fruit weight and number of marketable fruits per plant with marketable yield per plant was significantly positive, but their direct effect on marketable yield per plant was negative or negligible (Table 2).

Table 1. Phenotypic and genotypic correlation among seventeen quantitative traits of okra

Trait		Plant height (cm)	Number of branches per plant	Internodal length (cm)	Days to 50 % flowering	First flowering node	First fruiting node	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Total number of fruits per plant	Number of marketable fruits per plant	Total yield per plant (g)	Marketable yield per plant (g)	FSB infestation on	YVMV infestation on		
															Fruits %	Shoots %	Fruits %	Plants %
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1)	r_g	1.0000	0.4664**	0.9811**	-0.1136	-0.3885**	-0.3885**	0.7601**	-0.0884	0.4441**	0.7722**	0.7778**	0.7330**	0.7435**	-0.9606**	-0.5542**	0.2444**	0.2392*
	r_p	1.0000	0.3555**	0.5355**	-0.0555	-0.0926	-0.0926	0.4664**	0.0309	0.1746	0.7858**	0.7989**	0.6829**	0.7102**	-0.6192**	-0.4040**	0.1924	0.1994
(2)	r_g		1.0000	0.6053**	-0.5442**	-0.4707**	-0.4707**	0.6486**	0.0044	0.2740*	0.6850**	0.7002**	0.5901**	0.6219**	-0.9781**	-1.0378**	0.2299	0.2288
	r_p		1.0000	0.5355**	-0.1728	-0.1945	-0.1945	0.3684**	-0.0754	0.0900	0.4891**	0.4721**	0.4069**	0.4285**	-0.2764*	-0.8392**	0.2074	0.2155
(3)	r_g			1.0000	-0.4091**	-0.2896*	-0.2896*	0.7447**	-0.0701	0.3106**	0.8088**	0.8367**	0.7012**	0.7276**	-1.2174**	-0.7224**	0.2151	0.2184
	r_p			1.0000	-0.1806	-0.2346*	-0.2346*	0.3421**	-0.1964	0.0809	0.3802**	0.3778**	0.3338**	0.3651**	-0.2728*	-0.5249**	0.1999	0.1940
(4)	r_g				1.0000	0.3499**	0.3499**	-1.1208**	0.5285**	-0.2676*	-0.4471**	-0.3977**	-0.4710**	-0.4283**	0.1284	0.6780**	-0.6652**	-0.6928**
	r_p				1.0000	0.1173	0.1173	-0.1154	0.3064**	0.1036	-0.1287	-0.1349	-0.0653	-0.0642	0.1419	0.1203	-0.3334**	-0.3090**
(5)	r_g					1.0000	1.0000	-0.4739**	0.2494*	0.1217	-0.4219**	-0.3645**	-0.2893*	-0.2842*	0.0008	0.3807**	-0.0607	-0.0746
	r_p					1.0000	1.0000	-0.0481	0.2303	0.2295	-0.0816	-0.0895	0.0301	0.0074	0.1085	0.1470	-0.0519	-0.0346
(6)	r_g						1.0000	-0.4739**	0.2494*	0.1217	-0.4219**	-0.3645**	-0.2893*	-0.2842*	0.0008	0.3807**	-0.0607	-0.0746
	r_p						1.0000	-0.0481	0.2303	0.2295	-0.0816	-0.0895	0.0301	0.0074	0.1085	0.1470	-0.0519	-0.0346
(7)	r_g							1.0000	-0.9242**	0.3368**	0.8482**	0.8892**	0.7568**	0.7884**	-1.4263**	-0.8484**	0.4707**	0.4457**
	r_p							1.0000	0.1824	0.6355**	0.5922**	0.5836**	0.7188**	0.7064**	-0.3939**	-0.3829**	0.2523*	0.2862*
(8)	r_g								1.0000	0.3541**	-0.1327	-0.1130	-0.0260	-0.0210	0.0124	0.0049	0.1472	0.1301
	r_p								1.0000	0.5721**	0.1376	0.1207	0.3157**	0.2829*	-0.0120	0.1660	0.0522	0.0702
(9)	r_g									1.0000	0.7452**	0.7782**	0.8270**	0.8282**	-1.1921**	-0.4187**	0.6039**	0.5693**
	r_p									1.0000	0.3731**	0.3694**	0.6776**	0.6430**	-0.2526*	-0.0841	0.2555*	0.2911*
(10)	r_g										1.0000	1.0039**	0.9898**	0.9936**	-1.2461**	-0.8172**	0.4686**	0.4598**
	r_p										1.0000	0.9871**	0.9284**	0.9373**	-0.6595**	-0.5149**	0.3636**	0.3760**
(11)	r_g											1.0000	0.9991**	0.9986**	-1.1830**	-0.8274**	0.4527**	0.4468**
	r_p											1.0000	0.9135**	0.9377**	-0.7693**	-0.5144**	0.3468**	0.3556**
(12)	r_g												1.0000	1.0013**	-1.2772**	-0.7227**	0.5319**	0.5145**
	r_p												1.0000	0.9900**	-0.5970**	-0.4328**	0.3912**	0.4177**
(13)	r_g													1.0000	-1.2357**	-0.7462**	0.4874**	0.4737**
	r_p													1.0000	-0.6758**	-0.4604**	0.3685**	0.3906**
(14)	r_g														1.0000	1.0941**	-0.5847**	-0.6026**
	r_p														1.0000	0.3747**	-0.2553*	-0.2456*
(15)	r_g															1.0000	-0.2396*	-0.2380*
	r_p															1.0000	-0.1771	-0.1822
(16)	r_g																1.0000	1.0024**
	r_p																1.0000	0.9950**
(17)	r_g																	1.0000
	r_p																	1.0000

r_g = Genotypic correlation coefficient; rp = Phenotypic correlation coefficient

Table 2. Direct and indirect effects of quantitative traits on marketable pod yield of okra

Trait		Plant height (cm) (1)	Number of branches per plant (2)	Internodal length (cm) (3)	Days to 50 % flowering (4)	First flowering node (5)	First fruiting node (6)	Fruit length (cm) (7)	Fruit width (cm) (8)	Fruit weight (g) (9)	Total number of fruits per plant (10)	Number of marketable fruits per plant (11)	Total yield per plant (g) (12)	FSB infestation on fruits % (13)	FSB infestation on shoots % (14)	YVMV infestation on fruits % (15)	YVMV infestation on plants % (16)	'r' with marketable yield per plant (g)
(1)	G	**0.0209**	0.0097	0.0205	-0.0024	-0.0081	-0.0081	0.0158	-0.0018	0.0093	0.0161	0.0162	0.0153	-0.0200	-0.0116	0.0051	0.0050	0.7435^{**}
	P	**-0.0200**	-0.0071	-0.0107	0.0011	0.0019	0.0019	-0.0093	-0.0006	-0.0035	-0.0157	-0.0160	-0.0137	0.0124	0.0081	-0.0039	-0.0040	0.7102^{**}
(2)	G	-0.0363	**-0.0779**	-0.0471	0.0424	0.0367	0.0367	-0.0505	-0.0003	-0.0213	-0.0533	-0.0545	-0.0459	0.0762	0.0808	-0.0179	-0.0178	0.6219^{**}
	P	0.0102	**0.0287**	0.0154	-0.0050	-0.0056	-0.0056	0.0106	-0.0022	0.0026	0.0140	0.0135	0.0117	-0.0079	-0.0241	0.0059	0.0062	0.4285^{**}
(3)	G	-0.0022	-0.0014	**-0.0023**	0.0009	0.0007	0.0007	-0.0017	0.0002	-0.0007	-0.0018	-0.0019	-0.0016	0.0028	0.0016	-0.0005	-0.0005	0.7276^{**}
	P	0.0163	0.0163	**0.0305**	-0.0055	-0.0072	-0.0072	0.0104	-0.0060	0.0025	0.0116	0.0115	0.0102	-0.0083	-0.0160	0.0061	0.0059	0.3651^{**}
(4)	G	0.0030	0.0142	0.0107	**-0.0260**	-0.0091	-0.0091	0.0292	-0.0138	0.0070	0.0116	0.0104	0.0123	-0.0033	-0.0177	0.0173	0.0180	-0.4283^{**}
	P	-0.0010	-0.0032	-0.0033	**0.0185**	0.0022	0.0022	-0.0021	0.0057	0.0019	-0.0024	-0.0025	-0.0012	0.0026	0.0022	-0.0062	-0.0057	-0.0642
(5)	G	0.0105	0.0128	0.0079	-0.0095	**-0.0271**	-0.0271	0.0129	-0.0068	-0.0033	0.0115	0.0099	0.0079	0.0000	-0.0103	0.0016	0.0020	-0.2842^{*}
	P	-0.0004	-0.0009	-0.0011	0.0006	**0.0047**	0.0047	-0.0002	0.0011	0.0011	-0.0004	-0.0004	0.0001	0.0005	0.0007	-0.0002	-0.0002	0.0074
(6)	G	0.0105	0.0128	0.0079	-0.0095	-0.0271	**-0.0271**	0.0129	-0.0068	-0.0033	0.0115	0.0099	0.0079	0.0000	-0.0103	0.0016	0.0020	-0.2842^{*}
	P	-0.0004	-0.0009	-0.0011	0.0006	0.0047	**0.0047**	-0.0002	0.0011	0.0011	-0.0004	-0.0004	0.0001	0.0005	0.0007	-0.0002	-0.0002	0.0074
(7)	G	0.0070	0.0059	0.0068	-0.0103	-0.0043	-0.0043	**0.0092**	-0.0085	0.0031	0.0078	0.0081	0.0069	-0.0131	-0.0078	0.0043	0.0041	0.7884^{**}
	P	-0.0011	-0.0009	-0.0008	0.0003	0.0001	0.0001	**-0.0024**	-0.0004	-0.0015	-0.0014	-0.0014	-0.0017	0.0010	0.0009	-0.0006	-0.0007	0.7064^{**}
(8)	G	-0.0029	0.0001	-0.0023	0.0171	0.0081	0.0081	-0.0298	**0.0323**	0.0114	-0.0043	-0.0037	-0.0008	0.0004	0.0002	0.0048	0.0042	-0.021
	P	-0.0001	0.0002	0.0006	-0.0009	-0.0007	-0.0007	-0.0005	**-0.0029**	-0.0017	-0.0004	-0.0004	-0.0009	0.0000	-0.0005	-0.0002	-0.0002	0.2829^{*}
(9)	G	0.0008	0.0005	0.0006	-0.0005	0.0002	0.0002	0.0006	0.0006	**0.0018**	0.0013	0.0014	0.0015	-0.0021	-0.0007	0.0011	0.0010	0.8282^{**}
	P	-0.0039	-0.0020	-0.0018	-0.0023	-0.0051	-0.0051	-0.0142	-0.0128	**-0.0224**	-0.0084	-0.0083	-0.0152	0.0057	0.0019	-0.0057	-0.0065	0.6430^{**}
(10)	G	0.6679	0.5925	0.6996	-0.3868	-0.3650	-0.3650	0.7337	-0.1147	0.6446	**0.8650**	0.8683	0.8562	-1.0778	-0.7069	0.4053	0.3977	0.9936^{**}
	P	0.2045	0.1273	0.0989	-0.0335	-0.0212	-0.0212	0.1541	0.0358	0.0971	**0.2603**	0.2569	0.2416	-0.1716	-0.1340	0.0946	0.0979	0.9373^{**}
(11)	G	-0.8653	-0.7790	-0.9309	0.4424	0.4055	0.4055	-0.9892	0.1258	-0.8657	-1.1168	**-1.1125**	-1.1114	1.3161	0.9205	-0.5036	-0.4971	0.9986^{**}
	P	-0.2619	-0.1548	-0.1238	0.0442	0.0293	0.0293	-0.1913	-0.0396	-0.1211	-0.3236	**-0.3278**	-0.2994	0.2521	0.1686	-0.1137	-0.1165	0.9377^{**}
(12)	G	0.7500	0.6037	0.7174	-0.4819	-0.2960	-0.2960	0.7743	-0.0266	0.8461	1.0127	1.0222	**1.0231**	-1.3068	-0.7395	0.5442	0.5264	1.0013^{**}
	P	0.6573	0.3916	0.3213	-0.0628	0.0290	0.0290	0.6919	0.3039	0.6522	0.8936	0.8792	**0.9625**	-0.5746	-0.4166	0.3766	0.4021	0.9900^{**}
(13)	G	0.1546	0.1574	0.1959	-0.0207	-0.0001	-0.0001	0.2295	-0.0020	0.1919	0.2005	0.1904	0.2055	**-0.1609**	-0.1761	0.0941	0.0970	-1.2357^{**}
	P	0.1246	0.0556	0.0549	-0.0286	-0.0218	-0.0218	0.0793	0.0024	0.0508	0.1327	0.1548	0.1202	**-0.2013**	-0.0754	0.0514	0.0494	-0.6758^{**}
(14)	G	0.0553	0.1036	0.0721	-0.0677	-0.0380	-0.0380	0.0847	-0.0005	0.0418	0.0816	0.0826	0.0722	-0.1093	**-0.0999**	0.0239	0.0238	1.0941^{**}
	P	-0.0069	-0.0143	-0.0090	0.0021	0.0025	0.0025	-0.0065	0.0028	-0.0014	-0.0088	-0.0088	-0.0074	0.0064	**0.0171**	-0.0030	-0.0031	0.3747^{**}
(15)	G	0.1005	0.0946	0.0885	-0.2735	-0.0250	-0.0250	0.1936	0.0605	0.2483	0.1927	0.1862	0.2187	-0.2404	-0.0985	**0.4112**	0.4122	-0.2396^{*}
	P	0.0204	0.0220	0.0212	-0.0354	-0.0055	-0.0055	0.0268	0.0055	0.0271	0.0386	0.0368	0.0415	-0.0271	-0.0188	**0.1061**	0.1056	-0.1771
(16)	G	-0.1202	-0.1149	-0.1097	0.3481	0.0375	0.0375	-0.2239	-0.0653	-0.2860	-0.2310	-0.2245	-0.2585	0.3027	0.1196	-0.5036	**-0.5024**	1.0024^{**}
	P	-0.0278	-0.0301	-0.0271	0.0431	0.0048	0.0048	-0.0399	-0.0098	-0.0406	-0.0525	-0.0496	-0.0583	0.0343	0.0254	-0.1388	**-0.1395**	0.9950^{**}

G =Genotypic; P =Phenotypic; r= Correlation coefficient; Genotypic residual effect =0.0010; Phenotypic residual effect =0.9182

Under this condition, the indirect effects seem to be cause of correlation. In such situations, the indirect casual factors are to be considered simultaneously for selection.

The residual factor determines how best the casual factors account for the variability of the dependent factor, the marketable pod yield per plant in this case. The residual effects were 0.0818 and 0.001, which were of negligible magnitude at genotypic and phenotypic levels. The variables studied explain about 91.82% and 99.90% of the variability at genotypic and phenotypic levels, respectively in the marketable pod yield per plant.

Conclusion

In conclusion, the correlation coefficient analysis of seventeen quantitative traits revealed strong association among growth, earliness and yield parameters of okra under study. Total number of fruits per plant and total yield per plant had positively high and very high direct effects, respectively on marketable yield per plant. Further, these traits also had significantly positive correlation with marketable pod yield and positive inter-correlation also among themselves. Hence, total number of fruits per plant and total yield per plant were the important yield contributing characters, which need to be considered while framing selection criteria in okra breeding programmes. It can, therefore, be concluded that the traits *viz*., total number of fruits per plant and total yield per plant are the important yield contributing traits and due critical emphasis needs be given to these traits while selecting for marketable pod yield improvement in okra. The improvement in marketable pod yield per plant will be efficient, if the selection is based on total number of fruits per plant and total yield per plant.

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